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ABSTRACT

The American public continues to be perplexed by the substandard reading, math, and science skills of students. Science information alone is growing at a rate that will make it very difficult for many, especially students with feeble science knowledge and skills, to become scientifically literate. This research describes the development, distribution, and evaluation of a biomedical oriented newsletter named BioRap for sixth to eighth grade students. BioRap is designed in a weekly reader type format and provides current, relevant information to children in a more cost-effective manner. Expert faculty at major universities, research scientists at drug companies and hospitals, veterinarians, physicians, etc. serve as content resources for BioRap. Based upon data gathered from teachers who have used BioRap, it was concluded that BioRap has a strong potential for use in the classroom. Its short length allows flexibility in when and how teachers can introduce BioRap into the curriculum. It is believed that BioRap shows great promise as a vehicle to improve the science literacy of adolescents. (ZWH)

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ED 404 129

Can We Improve Science Literacy?[1]

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The American public continues to be perplexed by substandard reading and math skills of students. There is now broad evidence that science accomplishment is equally weak. That is especially troubling, considering that scientific information doubles every 10 to 15 years (Wilson, 1993). Students with feeble science knowledge and skills now face an increasing, cumulative deficit in their understanding and application of science. Biomedical and technological developments demand contemporary knowledge and language for informed consumption by the public. Textbook authors and publishers face major challenges maintaining currency in times of continual discovery. And schools are under great pressure to provide a strong science foundation to meet the demand of accelerating scientific sophistication.

This research describes the development, distribution, and evaluation of a biomedically oriented newsletter, **BioRap**, for sixth to eighth grade students. **BioRap** is sponsored by the nonprofit *Connecticut United for Research Excellence* (*CURE*). *CURE* was established as a consortium of institutions in Connecticut that expressed concern over student science literacy. Initially, a speakers' bureau was created to offer informed professionals who would speak in classrooms free of charge. Teacher requests for *CURE* speakers became so great that another vehicle—**BioRap**—was developed to provide current, relevant information to children in a more cost-effective manner. **BioRap** was planned as a *Weekly Reader* format for biomedical topics of interest to school children. Its purposes include inexpensive, wide distribution, and coverage of newer information than is possible in texts. **BioRap** content is presented in a variety of nontraditional ways that distinguish it from the usual textbook orientation. The same experts—faculty at major universities in the state, research scientists at drug companies and hospitals, veterinarians, physicians, etc.—who were speakers for *CURE* served as content resources for **BioRap**. A professional writer was engaged to provide the actual content presentation.

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[1]A paper presented at the annual meeting of the American Educational Research Association, New Orleans, April 1994.

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Evaluation of **BioRap** took several directions. *CURE* had intended the newsletter would not just raise scientific literacy of students, but also be effective across a range of grades, ability, socioeconomic and gender groups. **BioRap** was additionally meant to be amenable to incorporation into various types of classroom use without losing effectiveness. The specific objectives of the evaluation were to measure cognitive gains relative to **BioRap** content, and student reactions to different presentation formats within each issue. Student and classroom characteristics (age, gender, ability grouping), as well as method of use of **BioRap** (to award a grade, as supplementary material) were considered in relationship to student performance.

After a year of successful use of **BioRap** within Connecticut, distribution of the newsletter was expanded to six states through additional financial support from *Join Hands*. The current multistate distribution includes schools in California, Massachusetts, New Jersey, North Carolina, and Pennsylvania. Issues of **BioRap** were made available, free of charge, to teachers for classroom use. Teachers in turn agreed to use **BioRap** with their students, in any way they chose. They were requested to provide evaluation data, collected on a single sheet, to *CURE* for analysis of the effectiveness of **BioRap** when distributed beyond the originally targeted state.

Methods

Each issue of **BioRap** was planned as an eight-page newsletter to be printed on heavy, recycled and biodegradable paper. The issues would be targeted at current health concerns in which research and development was progressing rapidly. Each issue would have particular "columns" of a specific format and covering current information relevant to the theme of the issue. These formats include:

- a cartoon presentation of facts;
- a description (with photos) of the application of the scientific method to a contemporary problem;
- a focused profile of a health or science related career;
- a crossword puzzle with clue definitions of words presented in the issue;
- a section of bulleted information on disease prevention and treatment;
- a "word jumble" with scrambled letters forming vocabulary words introduced in the issue;
- a column with international extensions of issue information; and

- activities students can do on their own to explore content further.

Issues thus far distributed in Connecticut include one on measles and rabies, and a second on Lyme disease. A third issue on feline leukemia was the first to be distributed across the six states. It was developed as a lead into an AIDS issue that is being used in classrooms now (April 1994).

An evaluation sheet specific to each issue was constructed for students to complete. For each **BioRap** issue, multiple choice or matching content-based items were developed. Items were pilot tested and analyzed using a small a group of representative students. Criteria for item retention were that items had difficulty indices between .25 and .75 and discrimination indices greater than .20. The items were assessed for content validity and representativeness across the entire issue. Ten items were included on the achievement test portion of each evaluation sheet. In addition to these core items, three items were included that covered content to be presented in subsequent issues of **BioRap**. These items were intended to gauge the exposure of students to upcoming topics and were considered "pretest" estimates.

In addition to the content questions on the evaluation sheets, students indicated the letter grades they usually received in class, their age, and gender. They also awarded letter grades to specific sections of **BioRap** (A to their favorite and F to their least favorite), and an overall grade (A through F) to the total issue. On a separate sheet, teachers indicated for each class whether it was ability grouped and if so, what ability it included; the grade level of the class; whether the **BioRap** content test items were treated as a graded activity or not; and if the questions were answered in an open- or closed-book situation.

During the first year of distribution in Connecticut schools only, schools were identified as located in an urban, suburban or rural setting and by the socioeconomic status of the community the students came from. Once expanded distribution began, limited resources preempted identification of community socioeconomic status, so data were identified by state only.

Initial Data Source and Analyses. Within Connecticut, fourteen teachers in nine schools, each teaching multiple classes in grades six through eight, used **BioRap** during the first year of distribution (1992-1993). Schools were

originally selected by random sampling from a listing of schools in one major Connecticut county. This sample produced no school in a low income urban area. Subsequently an urban middle school was purposely included to increase diversity of school settings.

Data from approximately 2,000 student responses to the first two issues of **BioRap** have been analyzed. Although other self-selected students, teachers, and schools used **BioRap** during the first year, their responses have not been included in the initial analyses.

Initial Results. As a baseline estimate of science knowledge, means were calculated for the 3-item pretest portions that represented content on subsequent **BioRap** issues. For both issues of BioRap the means on these items showed approximately 40% accuracy in responding. By comparison, the overall average scores on the issue-specific, 10-item achievement test showed about 74% correct responding. Correct answers declined over the grades from 85% (6th graders) to 67% (eighth graders). Predictably, students in high ability classes outperformed those in middle ability and in low ability classes (79%, 73%, and 63% average performance, respectively). There were no sex differences in performance. It did make a difference if the quiz was to be used as part of a grade: 83% correct.

Economic disadvantage extracted no special toll on achievement. Low income urban students scored 66% correct as compared to 67% from their more advantaged peers. In the majority of cases, the **BioRap** achievement items were used as an ungraded assignment. Thus, these scores reflect student mastery *without* the incentive of a grade awarded.

The mean grade assigned by students to **BioRap**, across both of the initial issues and across all grade levels, was a **B**. Interestingly, the simple correlation between **BioRap** grade awarded and student achievement based upon the 10-item tests was -.32, meaning that it tended to be rated higher by students who scored worse. Students also assigned **A** and **F** grades to favorite and "yuk" **BioRap** sections. Here, individual differences reigned: Many students liked each of the 12 sections graded, while others disliked the same ones. The cartoon piece, in both issues, received simultaneously the most **A**s and the most **F**s. Contrary to our predictions, the word sections (jumble and crossword) received many high marks from students.

Expanded Distribution Data and Analyses. Data from the third issue of **BioRap**—covering feline leukemia—have been collected and analyzed from the six state distribution. Nearly 4000 students in grades six through eight completed the 10-item content test. Descriptive information about these students is given in Table 1. Achievement scores from these students shows remarkably consistent performance across **BioRap** issues regardless of content. Average score across the six states and three grade levels was 73.5% correct. Connecticut and Massachusetts students, in classes taught by teachers likely to have used **BioRap** during the previous year, achieved slightly higher average scores and showed smaller variability in scores than did students from other states (**M** = 75.5, 78.1; **SD** = 19.4, 17.8 for CT and MA, respectively).

Insert Table 1 here

Student responses on the pretest items addressing AIDS content (information covered in the issue currently being distributed) showed higher science literacy than for previously covered topics. Average percent correct on the brief three-item pretest was 53.5, with California students showing notably higher scores (**M** = 60.6) and Pennsylvania students showing the lowest pretest performance (**M** = 47.4).

The pattern of declining performance with increasing grade level that was noted initially was not evident in the expanded distribution data. Sixth and seventh grade students performed equivalently (72.8% and 72.9% correct, respectively) whereas eighth graders showed 75.5% correct responding. Student ability was again related to performance, with homogeneously grouped, high ability students achieving an average of 79.6% correct. Homogeneously grouped middle ability students showed 76.8% average performance, low ability and heterogeneously grouped classes 72.3% and 71.8% correct, respectively. There was again no practical difference in the performance of male as compared to female students (72.3% and 73.3% correct, respectively). The condition of having the 10-item test count toward a classroom grade was related to achievement outcome: graded work produced 76.4% mastery, and ungraded, 71.3% correct. An open-book testing condition showed 77.9% achievement, and closed book, 70.2%. A summary of the average performance of students, grouped by selected variables, is presented in Table 2.

Insert Table 2 here

Overall grades awarded to **BioRap** by the student consumers were again squarely in the B range. Connecticut and Massachusetts youngsters liked it best (**M** = 1.97 and 1.99 on a scale of 1 = A to 5 = F), with students from the other states showing average grades awarded between 2.10 and 2.30.

As with previous issues, there was wide variation in student preferences for the sections of **BioRap**. All sections received a fair share of A and F grades, with the cartoon again receiving simultaneously the largest proportion of both As and Fs. And as before, word games (crossword and jumble) got high marks from many students. Some student respondents elected to award only As, because they could not identify any section deserving an F! No gender related differences were found in student preference for sections. A summary of the grades awarded on the six state distribution of the feline leukemia issue is given in Table 3.

Insert Table 3 here

Data from the multistate distribution were subjected to a regression analysis to estimate what characteristics were most strongly related to student achievement on the 10-item achievement test. Two sets of variables were entered into the regression analysis in hierarchical order. The first set, arranged to represent demographic information, included data about student grade level (6th, 7th, or 8th, effect coded), gender, state of residence (effect coded), whether the testing condition was open or closed book, and if the test results would be counted toward a class grade. A second set of variables, constructed as proxy for student ability, included student self-report of typical classroom grades received and an effect coded indicator of the nature of the classroom grouping: heterogeneous; or homogeneously grouped as high, middle, or low ability.

The set of demographic variables accounted for approximately 8% of the variation in test scores (**R** = .29), with the open/closed book and graded/not graded test being the only significant predictors in the set. (Because the large sample resulted in excessive statistical power, significance tests were performed at $\alpha \leq .001$.) Accompanying these variables, state of residence explained no additional variation in student test scores. Within the ability set of variables,

self-reported previous grades was the only significant predictor, increasing prediction to better than 14% ($R = .38$). Table 4 summarizes this hierarchical regression analysis.

Insert Table 4 here

Discussion

The decline in achievement over grades 6 to 8 seen initially did not occur in the expanded distribution of **BioRap**. Aside from that difference, the expansion data generally follow the patterns noted initially. Lack of sex differences in achievement and grade awarded to **BioRap** runs contrary to the usual science stereotypes favoring males. Gender status does not appear relevant to achievement or satisfaction outcomes associated with **BioRap**. The comparison of pretest to posttest performance shows that students demonstrate significant and practically meaningful gains in knowledge of content after using **BioRap**. Gains occur under all sorts of teaching conditions, but achievement is maximized with the incentive of contingent grades for test results and when open book is allowed during testing.

In a univariate view, between-state differences in student performance occurred. However, the multivariate perspective—using regression analysis—showed that in combination with other variables, between state differences evaporated. We take the regression results to be supportive of **BioRap** as a means to improve science literacy. Its effectiveness is independent of unalterable variables such as grade level, gender, and state of students' residence. Motivational variables (graded or not graded test results) and testing condition (open or closed book) are under teacher control and might be manipulated depending on teachers intentions about how students ought to use **BioRap**. In short, teachers have some latitude about instructional conditions with **BioRap**.

The relationship between student ability, as represented by self-reported history of grades, was not unexpected. Students with higher achievement histories typically perform better in academic situations than do those with lesser previous achievement. The multiple choice, objective format of the posttest measure is a commonplace example of academic tasks students face in classrooms and it is consistent with factors that contribute to student grades.

Future assessment of outcomes of **BioRap** use might explore other less traditional outcome variables aside from academic achievement. One such alternate variable is student self-efficacy. Bandura (1986) has made the strong case that efficacy judgments have causal influence on behavior. Thus, if students' science self-efficacy is enhanced by **BioRap**, they are more likely to approach, engage in, and succeed at science-related tasks. If students show a stronger sense of confidence or efficacy for science skills or, ultimately, for careers in science, after **BioRap** exposure there would be additional support for the newsletter's classroom use. Assessment of self-efficacy as an outcome variable would also address interest in documenting effects of schooling beyond academic or achievement gains alone.

Clearly students enjoy **BioRap**. The grades they award to what is essentially a classroom teaching tool are remarkably high and consistent across state, gender, and issue. There seems to be some section of **BioRap** that appeals to each student, and certain ones that appeal to many. Such stimulus variety improves attention and motivation (Owen, Froman, and Moscow, 1981), and judging from the spread of grades awarded to individual sections of **BioRap**, the diversity in newsletter format may improve student motivation for science achievement. The high grades given to the word puzzles are particularly encouraging. These sections give an additional reinforcement for learning beyond merely reading didactic presentations of information. They help students to rehearse information they were exposed to in some other part of each issue, as well as actively engaging students in practicing vocabulary. The enactive nature of the word games should help students to rehearse and place information into long term storage for future reference (Anderson, 1989).

BioRap has a strong potential for use in the classroom. Its slick newsletter formatting engages and interests students. Its short length allows flexibility in when and how teachers introduce **BioRap** into the curriculum. Production time for each issue has decreased: Only six months was needed to generate the most recent issue. The relatively inexpensive cost for production makes it amenable to frequent revision to maintain contemporary information with continued advances in the topics presented. Given evaluation data collected to date, **BioRap** shows great promise as a vehicle to improve science literacy of adolescents.

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Table 1

Descriptive Information for Sample*

	N	% of Sample
State		
California	608	15.5
Connecticut	480	12.2
Massachusetts	1192	30.3
New Jersey	601	15.3
North Carolina	713	18.1
Pennsylvania	336	8.5
Grade in school		
Sixth	755	20.6
Seventh	2225	60.7
Eighth	681	18.6
Student Gender		
Male	1530	48.6
Female	1616	51.3
Test Results Counted for Classroom Grade		
No	2064	55.2
Yes	1673	44.8
Testing Condition		
Open book	1209	39.2
Closed book	1259	40.8
Classroom Grouping		
Heterogeneous	2587	70.6
High ability	498	13.6
Middle ability	249	6.8
Low ability	255	7.0

* Total sample=3932 cases. Some percents total less than 100 due to missing data.

Table 2

Average Test Performance by Selected Grouping Variables

	Mean % Correct	SD
State		
California	69.96	22.15
Connecticut	75.54	19.45
Massachusetts	78.08	17.78
New Jersey	72.69	20.57
North Carolina	68.68	20.49
Pennsylvania	68.98	20.13
Grade		
Sixth	72.81	20.06
Seventh	72.92	20.33
Eighth	75.47	19.41
Student Gender		
Male	72.30	20.60
Female	73.30	19.61
Test Results Counted for Classroom Grade		
No	71.34	20.60
Yes	76.34	19.09
Testing Condition		
Open book	77.91	19.25
Closed book	70.17	19.80
Classroom Grouping		
Heterogeneous	71.76	20.63
High ability	79.63	17.12
Middle ability	76.77	17.49
Low ability	72.28	21.08

Table 3

A and F Grades Awarded to Sections of BioRap

	% of As Awarded	% of Fs Awarded
Cover story	13.9	10.8
Today's Research Lab	6.8	9.7
Career Rap	3.4	14.9
In Fact Bullet Bits	2.4	5.6
Crossword	12.1	10.4
Bag It Activities	2.8	8.6
Cartoon	23.8	11.9
Body System	5.1	7.3
Rap Sheet Fast Facts	3.0	6.5
Word Jumble	17.1	4.6
Facts Around the World	4.1	6.7
Photographs	5.4	2.8

Grades awarded from multistate distribution only. Percents do not total to 100 because of missing data.

Table 4
Summary of Hierarchical Regression

Variable	*b*	se_b	*ß*	*F*	*p*
Demographic Set				14.13	<.001
sex	.55	.93	.01		
graded/not graded	3.61	1.15	.09		<.001
open book/not	-5.99	1.27	-.16		<.001
CA	-2.71	2.12	-.06		
CT	2.47	2.49	.05		
MA	5.32	2.06	.11		
NJ	3.21	2.43	.06		
NC	-6.81	2.45	-.14		
grade 6	.26	1.65	.01		
grade 7	-3.56	1.77	-.09		
Ability Set				27.24	<.001
GPA	3.19	.34	.23		<.001
group: hetero.	1.73	1.64	.04		
group: high abil.	7.17	2.87	.09		
group: middle	5.56	2.44	.07		